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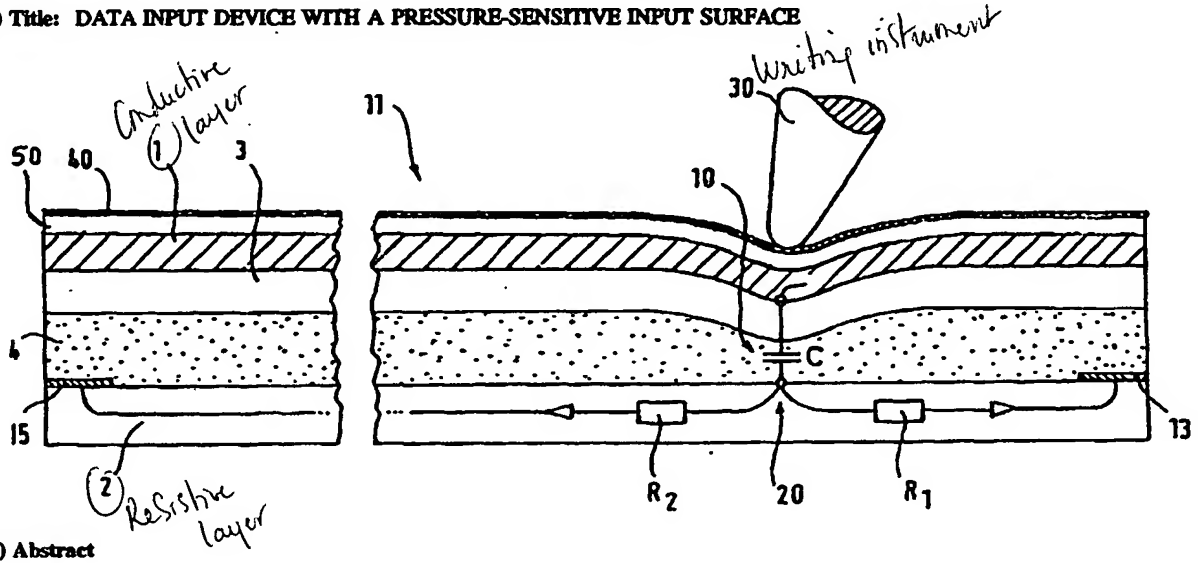

(57) Abstract

The data input device is provided with an input surface (40) which, by means of a pen, a writing instrument or the like, is locally subjected to a pressure or a pressing force. Below the input surface, there is arranged a sensor means for detecting at least the current position of the pen or writing instrument and for outputting output signals representing said position. Between the input surface and the sensor means, a color-change layer (50) is provided for temporary optical display of the position on the input surface (40) run over by the pen, writing instrument (30) or the like. The color-change layer (50) is responsive to the writing pressure exerted by the pen, writing instrument (30) or the like, and changes its color in those regions of the input surface which are run over by the pen, writing instrument (30) or the like. After lapse of a predetermined length of time after the input surface has been touched by the pen, writing instrument (30) or the like, the color-change layer (50) resumes its condition prevailing prior to said touch.

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Data input device with a pressure-sensitive input surface

The present invention is concerned with a data input device having a pressure-sensitive input surface, comprising an input surface adapted to be locally exposed to a pressure or a pressing force particularly by a pen, a writing instrument or the like, a sensor means arranged below the input surface for detecting at least the current position of the pen or the writing instrument and for outputting output signals representing this position, and an evaluating means for evaluating the output signals of the sensor means for detection of the position of the pen or writing instrument.

By use of such data input devices, it is possible to convert handwritten notes, for example signatures, into computer readable data. Subsequently, these data can be processed by the computer such that the signature trace resulting from the position signals is reconstructable and smoothable to a degree that allows the exact com-

parison with a signature already stored in the computer.

Devices for data input via pressure-sensitive input surfaces are known from EP-0 032 013 A3, EP 0 194 861 A2, EP 0 288 692 A2 and U.S. Patent 4,636,582. All of these known data input devices comprise a sensor means arranged below the input surface for detecting at least the current position of the pen or writing instrument and for emitting output signals representing this position. The sensor means is connected to an evaluating means for detecting the position of the pen or writing element. A certain problem involved with this type of data input devices consists in that the signature applied onto the writing surface by the pen, the writing instrument or the like, cannot be rendered optically recognizable.

From EP-0 189 590 A2, there is known a device for the input of information by a writing instrument with simultaneous display of this information. This device comprises two groups of strip electrodes arranged at a distance from each other, i.e. mutually parallel row electrodes and also parallel column electrodes extending orthogonally thereto. The space between both electrode groups is filled with a liquid crystal. Each of the row and column electrodes is provided with a driver. The column electrodes further comprise an input sensor connected in parallel to the driver. All of the electrodes are driven according to the time-division multiplex method. In addition, the input sensors are

scanned successively. The drive and control electronics required for these processes are relatively complex. By the writing instrument, the distance of the column electrodes to the row electrodes is locally reduced whereby the resistance and/or the capacitance in the area where the column electrodes exposed to the writing pressure cross the row electrodes, is changed. This is detected by the input sensors. By corresponding control of the thus localized electrodes via the associated drivers, the liquid crystal layer is caused to display the information written by the writing instrument.

Although the information inputting device according to EP-0 189 590 A2 allows optical representation of the inputted information, it requires an LCD display with a large number of input sensors to this purpose, so that this known device is very complicated in construction and manufacture.

It is an object of the present invention to provide a data input device comprising a pressure-sensitive input surface, which is capable of temporary optical display of the handwriting applied to the pressure-sensitive input surface in a simple and yet reliable manner.

For solving the above object, there is proposed, in accordance with the invention, a data input device having a pressure-sensitive input surface of the above type, wherein between the input surface and the sensor means there is arranged a layer arrangement for temporary optical display of the position on the input surface

held by the pen, the writing instrument or the like, said layer arrangement for temporary optical display being responsive to energy supply occuring upon touch of the input surface, and, after lapse of the predetermined length of time after said touch, resuming its condition prevailing prior to said touch.

In the data input device according to the invention, the input surface and the sensor means have a layer arrangement disposed therebetween for temporary optical display of the writing trace produced by the pen. Exactly speaking, the layer arrangement allows temporary optical display of those positions on the input surface whereon the latter is contacted by the pen or the writing instrument. For optical display, the layer arrangement is responsive to an energy supply which takes place when the input surface is touched by the pen or writing instrument. When, after touching a position on the input surface, this position has not been touched for a predetermined length of time, the layer arrangement in this area returns to its pre-touch condition. This can be effected either automatically or by external manipulation (exposure to light, heating of the layer structure or generation of an electric, magnetic or other field to which the layer arrangement is exposed).

Preferably, the layer structure comprises a layer of viscous, opaque, locally displaceable material arranged below the input surface, and a further layer being in contrast to said viscous material and being arranged

below said first mentioned layer. While not being subjected to pressure through the input surface, the layer of viscous material is substantially light-impermeable. As soon as the writing instrument, via the input surface, exerts pressure onto the layer, the viscous material is displaced so that the thickness of the layer is locally reduced. The layer of viscous opaque material is provided in such a manner that already by low writing pressures the viscous material is almost completely displaced, so that now the layer below the layer of viscous material, being of a contrasting color, becomes visible through the transparent input surface. In case of layers having a small thickness relative to the layer thickness without application of pressure, the viscous material is already transparent. Because of the viscosity of the opaque material, it will be only after a certain delay that the opaque material again fills the displacement areas which before had been freed from the viscous material by the pressure of the writing instrument, and the layer arrangement returns to the condition which existed before the writing instrument touched the input surface.

Preferably, the changing of the color of the layer arrangement in those regions wherein a writing pressure has been exerted on the input surface by the writing instrument is effected in chemical manner. To this effect, it is provided according to an advantageous embodiment of the invention that the layer arrangement consists of a material comprising photochromic chemical compounds, and that the pen, writing instrument or the

like has a light source arranged therein by which the layer arrangement, when the pen or writing instrument glides over the input surface, is locally illuminated through the input surface for obtaining a local change of color of the layer arrangement. After the input surface has been run over by the pen, writing instrument or the like, the layer arrangement has changed color corresponding to the writing trace, which is visible through the transparent input surface. Photochromic chemical compounds are known per se. These compounds have a specific half-value period which is a measure for the point of time when they take on their original (color) or chemical condition after one-time exposure. In the layer arrangement of the data input device of the invention, the reversibility is of decisive importance, i.e. the transition into the original condition after writing has been performed onto the input surface. Photochromic chemical compounds whose electrodes are excited and brought into a state of increased energy by the exposure, will fall back into their original energy condition in the course of time, thus releasing heat which is transmitted into the environment. Alternatively, for the layer arrangement of the data input device of the invention, it is possible to provide materials which are thermally and photochemically reversible, i.e. can be returned into their original state by exposure to light or heat supply.

Instead of photochromic chemical compounds, also thermochromic chemical compounds can be used as materials for the layer arrangement of the device of the inven-

tion. Preferably, in such a case, the writing instrument has a heat source arranged therein for locally heating the layer arrangement through the input surface while the writing instrument glides over the input surface, in order to effect a local change of color of the layer arrangement. With a corresponding configuration of the thermochromic compounds, the local heating could be generated by using the action of the pen pressed onto the input surface and running over it in the pressed-on condition, for thus generating frictional heat in the layer arrangement by which the thermochromic chemical compounds are changed in color.

Preferably, there is selected a layer arrangement which locally changes its color due to the pressure or press-on force of the pen or writing instrument.

An embodiment of the invention will be explained in greater detail hereunder with reference to the drawing.

Fig. 1 shows a longitudinal section through the different layers of the data input device, where in the intermediate arrangement of deformable dielectric layers below the trough-like depression at the contact point of the writing instrument, the narrowing of this dielectric layer and the major part of the thereby produced capacitance in the dielectric layer is represented by a schematically drawn capacitor, which is connected to a voltage divider with

the partial resistances R_1 and R_2 located in the lower resistive layer;

Fig. 2 shows an evaluation means of the data input device for connection to the partial resistances of the voltage dividers which are produced respectively below the depression inside the resistive layer and the capacity C of the dielectric layer occuring thereabove, the total layer arrangement being partially shown in exploded view;

Fig. 3 shows a filtering circuit, as it appears when omitting the analogue switches for the x- and y-coordinate; and

Fig. 4 illustrates the jump response function of the filtering circuit according to Fig. 3.

As can be seen from the sectional view of the data input device 11 in Fig. 1, the device is composed of a thin and insulating upper cover-layer (40) in which the writing pad (write-in area) is provided. Below this cover layer 40, there is arranged a color-change layer 50 which locally changes color in those regions where the cover layer 40 is subjected to a writing pressure by the tip of a writing instrument 30. Thus, in all of those areas where the cover layer 40 has been run over by the writing instrument, the color-change layer 50 will change its color, whereby e.g. a signature given by means of the writing instrument 30 is optically

represented on the color-change layer 50. After a certain span of time, the color-change layer 50 returns to its original color state. Below the color-change layer 50, the conductive layer 1 (shown by hatched lines) and below this the separate resistive layer 2 are located. Between the conductive layer 1 and the resistive layer 2, there is arranged an electrically insulating layer arrangement comprising the layers 3 and 4 and having dielectric characteristics. The group of layers comprising the layers 1 to 4 constitutes the sensor means by which both the x/y-position of the writing instrument 30 within the input surface and the pressure acting on the input surface are detected.

In order to avoid a direct electric contact between the conductive layer 1 and the resistive layer 2 in the case of pressure on the writing instrument, schematically shown at 30, on the input surface and the dimple-like depression (see Fig. 1) created hereby in the layer arrangement, an insulating layer 3 made of a thin flexible insulating material (for example PVC) and a layer 4 of dielectric material contacting the resistive layer 2 are situated between layers 1 and 2. The dielectric material is flexible in such a manner or made of such an elastic solid material or liquid displaceable material that, upon pressure of the tip of the writing instrument 30, a dimple-like depression is likewise formed in layer 4 under the pressure point, so that a decrease of the layers thickness is produced there. An elastic rubber, having a large dielectric

constant, can also be employed as a dielectric material.

As can be seen from the schematic view of Figure 1, the formation of a more or less pronounced depression (depending on the pressure of the writing instrument 30 on the elastic and flexible layer system), which is protruding into the elastic dielectric material and dislocating it from the space between the insulating layer 3 and the resistive layer 2 is observed. The capacitance "C" of a capacitor 10, which is shown symbolically in the compression of the dielectric material 4, is changed accordingly, wherein at the same time the major part of the thus produced change of capacitance is located between the bottom of the depression and the resistive layer. Such a change of capacitance is measurable the better, the higher the absolute value of the capacitance is. For that reason, a material of maximum possible dielectric constant is used in layer 4. In difference to the circuit of the data input device in U.S. Patent 4,636,582, in which the upper conductive layer 1 is connected directly to the midpoint of the voltage divider R_1,R_2, only one pole of the capacitor "C" is connected to the voltage divider in 20 in Figure 1.

The absence of a direct electric contact between the upper conductive layer 1 and the resistive layer 2 results in a longer lifetime and a higher reliability of the data input device.

As can be seen from the circuit for data collection according to Figure 2, this circuit consists of an evaluation circuit having four leads to the terminals 12,13,14,15 of the resistive layer 2 of the data input device 11 and an additional lead to a terminal 16 of the conductive layer 1, wherein a connection with an operational amplifier 18 is made in the way shown in Figure 2. Herein a switching between the two coordinate axes x,y of the resistive layer 2 having rectangular shape is achieved by two alternating switches with three contacts (for example semiconductor based analogue switches), wherein those switches are also triggered by a control unit 21 controlling the still-to-be-described evaluation of signals. By these connections a filtering circuit 17 is produced, shaping the frequency- and phase spectrum resulting from the switchable reference voltage source 7,8 in such a manner that by taking samples at the output, the interesting electric properties can be obtained as functions of the position of the tip of writing instrument 30 and the writing pressure acting onto the writing area.

The switchable reference voltage source 7,8 consists of an analogue switch S_1 and a Zener diode 7, which provides the input voltage for the filtering circuit 17 which consists of the resistance R before the inverting input of the operational amplifier 18, this operational amplifier and the actual data input device 11 with its five leads (four leads to the terminals 12,13,14,15 on the resistive layer 2 and one lead 16 to the conductive

layer) as well as two analogue switches S_2,S_3 for allowing a separate measurement in x- and y-direction.

The inverting input of operational amplifier 18 is connected, on the one hand, to the switchable reference voltage source via the resistance R and, on the other hand, to the conductive layer 1 of the data input device or its input 16, respectively. The output of the operational amplifier 18 is connected via the analogue switch S_2 to the terminals 12,13 of the resistive layer 2, and its terminals 14,15 are connected by a further analogue switch S_3 to ground or the reference potential for connection to the opposing transversal or longitudinal sides of the resistive layer 2. It is therein twice a lead connected to the resting poles of the analogue switches S_1,S_2, one lead connected to the transversal and one lead connected to the longitudinal direction. The output of the operational amplifier is connected to the moving pole of one of the analogue switches, and the reference point or the ground is connected to the movable pole of the other analogue switch. The switching of the two analogue switches has to be performed in a way that allows an independent measurement in transverse and longitudinal direction.

By using the filtering circuit 17 in which the data input device is provided, the thus resulting jump response function is analyzed at least at two discrete times t_1 and t_2 by taking samples at the output of the filtering circuit. From the form of the obtained jump

response function, the interesting quantities for position and pressure are obtained unambiguously.

The output of the filtering circuit 17 is therefore connected to two sample-and-hold amplifiers 5,6 which are each followed by an analogue-to-digital converter 19. The sample-and-hold amplifiers allow to take and to store measured points at arbitrary times determined by the control unit 21. The switches S_1,S_2 and S_3 are triggered by this control unit 21 as well.

Figure 3 shows the filtering circuit 17 as resulting when the terminals 13 and 15 are electrically connected to the operational amplifier 18. In this circuity, the x-coordinate (and the writing pressure) can be determined on the basis of the voltage devider R_1,R_2 and the capacitance C. The following description applies in a corresponding manner to a circuity in which the terminals 12 and 14 are electrically connected to the operational amplifier 18 in order to determine the y-coordinate (and, if desired, the writing pressure) on the basis of the voltage devider R'_1,R'_2.

A detailed analysis of this circuit shows that the transfer function is given by equation (1):

$$\frac{U_A}{U_E} = -\left(\frac{1}{i\omega RC}\left(1 + \frac{R_1}{R_2}\right) + \frac{R_1}{R}\right) \qquad (1)$$

For reasons of greater simplicity the resistance "R" has been chosen to be equal to the total resistance of

the data input device in one direction ($R=R_1+R_2$). (In y-direction in which between the terminals 12 and 14 there is formed the voltage devider resulting from the partial resistances R'_1, R'_2, the condition $R=R'_1+R'_2$ can be fulfilled in that the specific resistance or the resistance per area unit of the resistive layer in y-direction is different from that in x-direction. In case of an identical specific resistance or resistance per area unit in x- and y-direction, the switch S_2 or S_3 and the terminal pair comprising the less remote terminals 12,14, can have an additional resistance R' connected therebetween, thus obtaining the condition $R=R_1+R_2=R'_1+R'_2$. If, as mentioned in the introductory part of the specification there are provided two filtering circuits adapted to be alternately connected to the different terminal pairs and comprising respectively a operational amplifier and a resistance R or R', respectively between the non-inverting input and the reference voltage source, then the resistances can be dimensioned such that the conditions $R=R_1+R_2$ and $R'=R'_1+R'_2$ are met.)

It can be seen that equation (1) is basically composed of two terms, one constant term which reflects the position of the tip of the writing instrument, and an integrating term containing the capacitance "C". In order to elucidate the behavior of the circuit in the time domain, $i\omega$ is replaced by the Laplace variable "s" and the jump response of the circuit is obtained by Laplace transformation.

$$\hat{U}_A = -U_{E_0} \cdot \frac{1}{S} \left(\frac{1}{SR \cdot C} \left(1 + \frac{R_1}{R_2} \right) + \frac{R_1}{R} \right)$$

$$= -\frac{1}{S^2} \frac{U_{E_0}}{R \cdot C} \left(1 + \frac{R_1}{R_2} \right) + \frac{1}{S} \frac{U_{E_0} R_1}{R}$$

$\frac{1}{\uparrow} LT$ $\qquad$ $\frac{1}{\uparrow} LT$

$$\Rightarrow \quad U_A(t) = -t \frac{U_{E_0}}{R \cdot C} \left(1 + \frac{R_1}{R_2} \right) - \frac{U_{E_0} R_1}{R} \qquad (2)$$

Considering absolute values of the output voltage U_a, equation (2) can be represented as shown in Figure 3, being the jump response function of the circuit 17.

The curve shows a jump of the height $a=U_{E0}x(R_1/R)$ followed by a ramp having the slope $b=U_{E0}/(RxC)x(1+R_1/R_2)$. It is thus obvious that by evaluation of a, the pen position (in a coordinate) can be obtained, since it is proportional to R_1 and we know the voltage E_{E0} and the resistance R. With this, the resistance R_2 can also be calculated easily and with the help of b the capacitive "C". Assuming the model of a plate capacitor for the capacitance "C", it is known from electrostatics that the value of the capacitance is inversely proportional to the distance of the plates, in the present case the bottom of the compression and the resistive layer. Now, use is made of the fact that b is also inversely proportional to the capacitance. Thereby b is altogether proportional to the distance of the compression and the resistive layer and thus a measure for the pressure of the pen onto the surface. In order to obtain a and b, corresponding to the abscissa and the slope of a line,

independently of each other, two points at different times are necessary. For that reason, two separate sample-and-hold amplifiers are used. For transforming the analogue signals delivered by these amplifiers into digitalized form, both amplifiers have an analogue-to-digital converter 19 connected at their output side. The outputs of the analogue-to-digital coverters 19 are connected to an evaluating circuit 22 in which - controlled by the control unit 21 - the delivered digital signals are to be evaluated in the above described manner for obtaining the x- or y-coordinate and the writing pressure.

By taking at least two samples at two discrete times t_1,t_2 from the jump response function of the filtering circuit 17, sampling of the measured values for the calculation of the position coordinates (in x- and in y-direction) and the magnitude of the pressure, can be performed immediately after switch-on of the reference voltage (voltage jump). An extrapolation of the jump response function based on the two samples is thus possible, giving evidence for the slope b and the abscissa a of the jump response function (at its switch-on time).

By suitably frequent and fast switching of the alternating switches S_2 and S_3, the x- as well as the y-coordinate can be detected, in addition to the writing pressure, practically at every point which is run over by the writing instrument 30. By suitably frequent switch-on of the reference voltage (switching of switch

S_1), the writing pressure, the x- and the y-coordinate can be detected practically at every point of a (pressure) line generated by the writing instrument 30. After being evaluated, the digital signals delivered by the analogue-to-digital coverters 19 can e.g. be stored as a writing pressure and x/y coordinates for later performing a comparison with stored values relating to a signature in order to verify the authenticity of that signature.

Claims

1. A data input device having a pressure-sensitive input surface, comprising
   - an input surface adapted to be locally exposed to a pressure or a pressing force particularly by a pen, a writing instrument (30) or the like,
   - a sensor means (1-4) arranged below the input surface, for detecting at least the current position of the pen or the writing instrument and for outputting output signals representing said position, and
   - an evaluating means (17) for evaluating the output signals of the sensor means (1-4) for obtaining the position of the pen or the writing instrument,

   c h a r a c t e r i z e d i n
   - that a layer arrangement (50) is provided between the input surface and the sensor means (1-4) for temporary optical display of the position on the input surface run over by the pen, the writing instrument (30) or the like, said layer arrangement (50) for temporary optical display being responsive to energy supply occuring upon touch of the input surface, and, after lapse of a predetermined length of time after said touch, resuming its condition prevailing prior to said touch.

2. The data input device according to claim 1, characterized in that the layer arrangement (50) comprises a layer of viscous, opaque, locally displaceable material arranged below the input surface, and a layer arranged below said layer and contrasting to said viscous material.

3. The data input device according to claim 1, characterized in that the layer arrangement (50) consists of a material comprising photochromic chemical compounds, and that the pen, the writing instrument (30) or the like has a light source arranged therein by which the layer arrangement (50), when the input surface is run over, is locally illuminated through the input surface for obtaining a local change of color of the layer arrangement (50).

4. The data input device according to claim 1, characterized in that the layer arrangement (50) consists of a material comprising thermochromic chemical compounds.

5. The data input device according to claim 4, characterized in that the pen, the writing instrument (30) or the like has a heat source arranged therein for locally heating the layer arrangement (50) through the input surface while the input surface is run over, for obtaining a local change of color of the layer arrangement (50).

6. The data input device according to claim 1, characterized in that the layer arrangement (50) locally changes its color due to the pressure or the pressing forec.

FIG.1

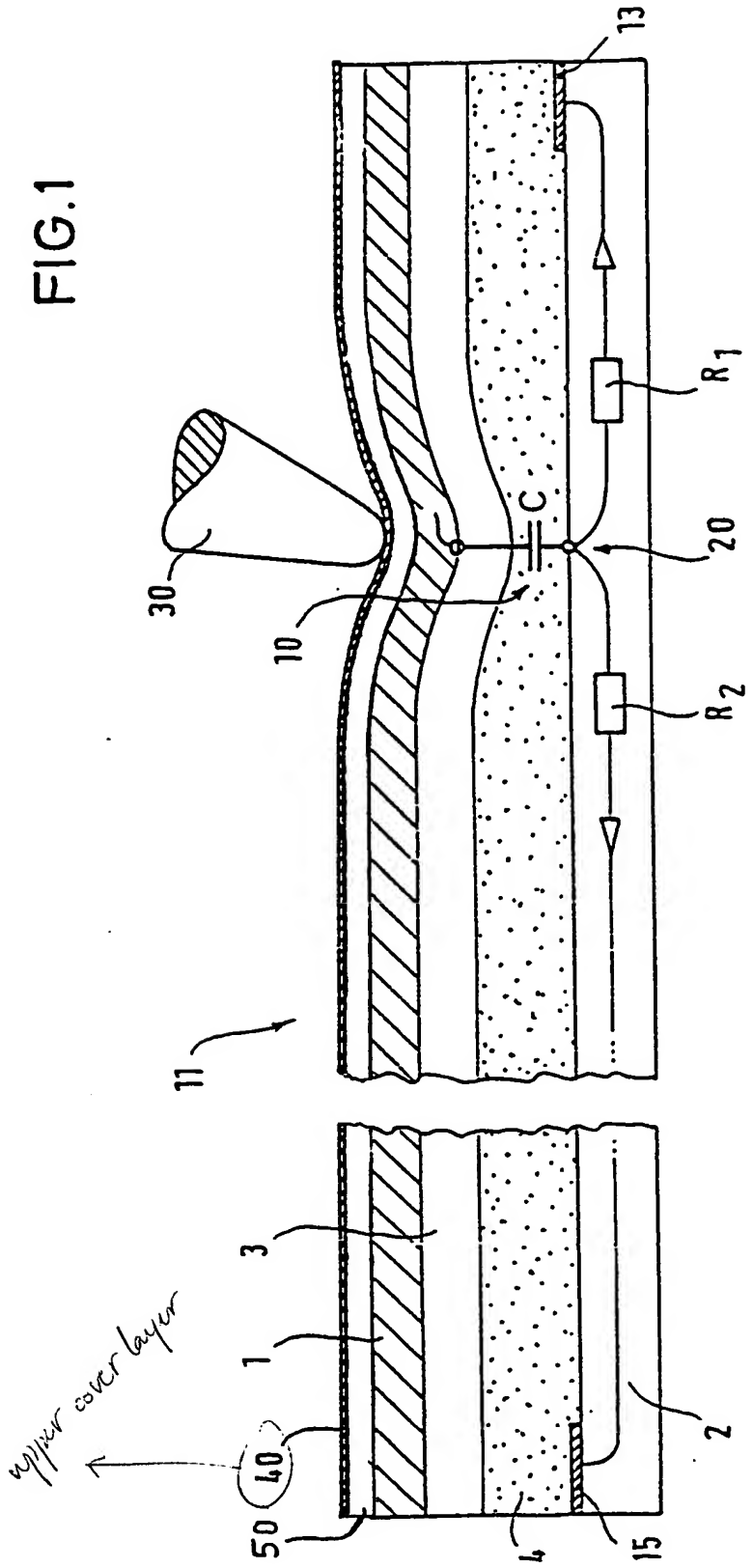
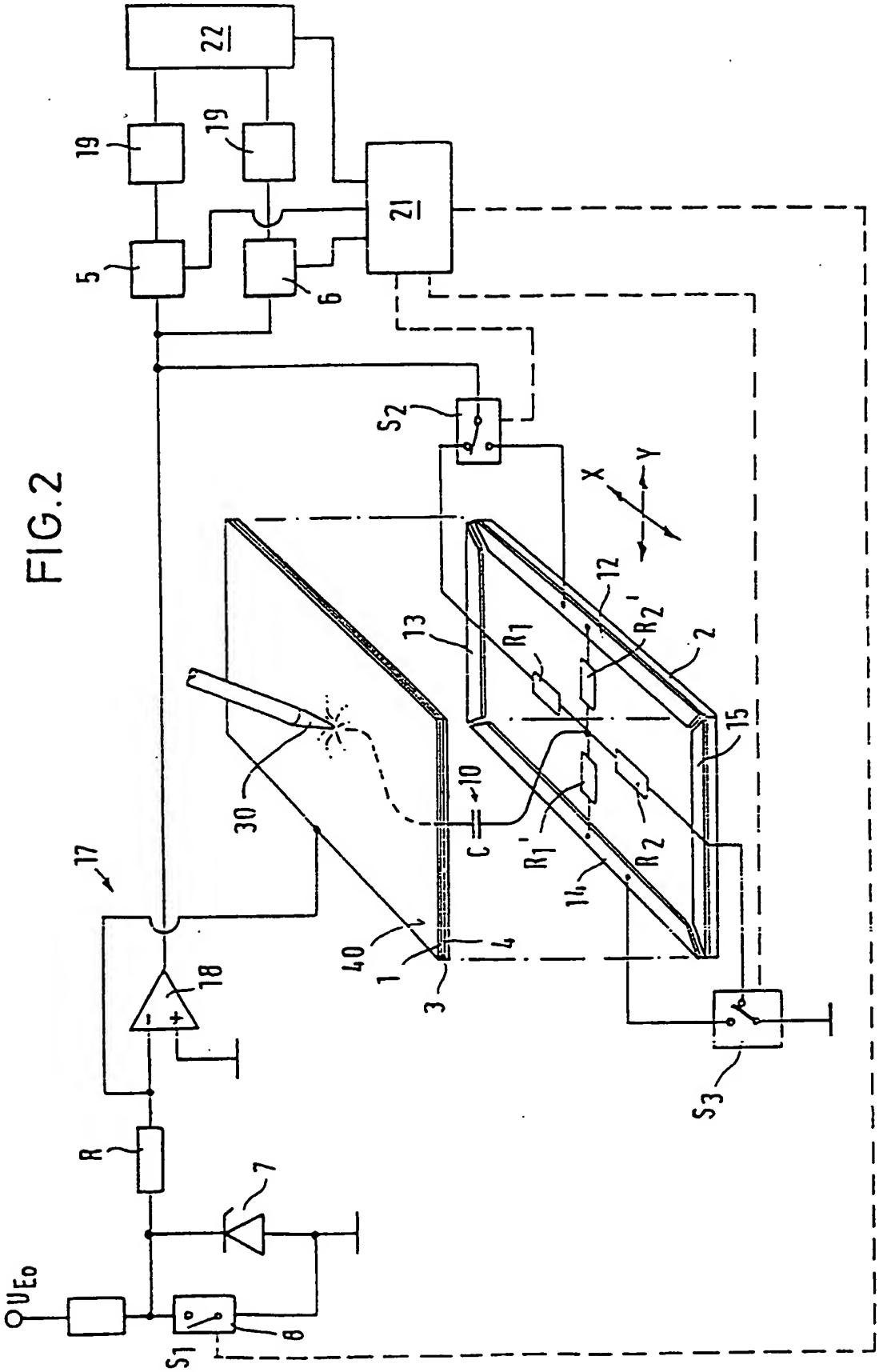


FIG.2


22
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19
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Y
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R1
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UE0
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S1

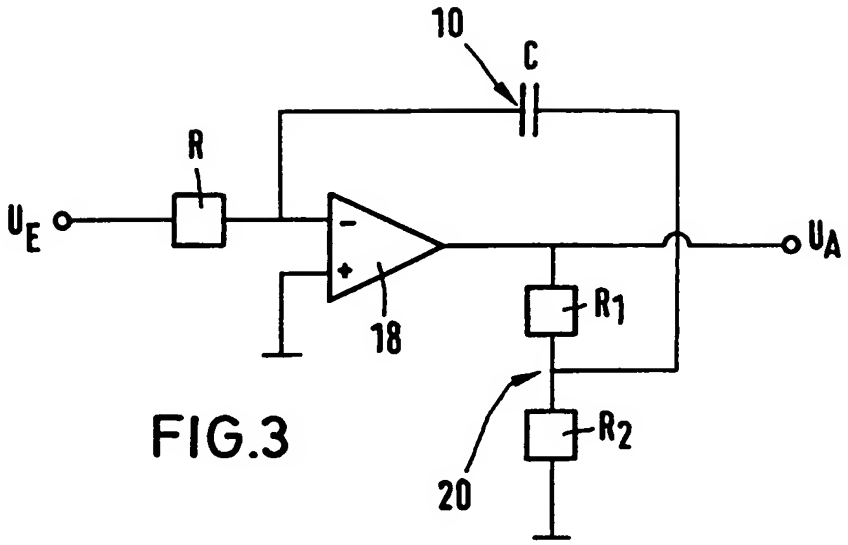

FIG.3

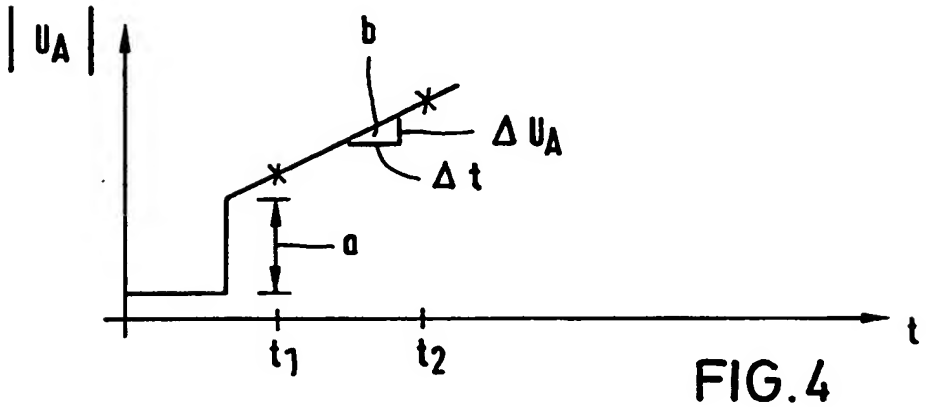

FIG.4

$$a = \left(\frac{U_{E0} \cdot R_1}{R}\right)$$

$$b = \left(\frac{\Delta U_A}{\Delta t} = \frac{U_{E0}}{R \cdot C}\left(1 + \frac{R_1}{R_2}\right)\right) P \sim \frac{1}{C}$$

INTERNATIONAL SEARCH REPORT

Intn nal Application No
PCT/EP 93/03452

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 G06F3/033 G06K11/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 G06F G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 066 965 (SECRETARY OF STATE FOR DEFENCE UK) 15 December 1982 see page 2, line 26 - page 11, line 19; figures	1-6
X	PATENT ABSTRACTS OF JAPAN vol. 14, no. 98 (P-1011)22 February 1990 & JP,A,01 303 487 (TOYOBO CO LTD) 7 December 1989 see abstract	1,3-5
A	EP,A,0 032 013 (MOORE BUSINESS FORMS INC) 15 July 1981 cited in the application see page 2, line 18 - page 12, line 2; figure 1	1,2

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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